Investigating the Role of Student Ownership in the Design of Student-facing Learning Analytics Dashboards (SFLADs) in Relation to Student Perceptions of SFLADs

by

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ABSTRACT

Learning analytics application is evolving into a student-facing solution. Student-facing learning analytics dashboards (SFLADs), as one popular application, occupies a pivotal position in online learning. However, the application of SFLADs faces challenges due to teacher-centered and researcher-centered approaches. The majority of SFLADs report student learning data to teachers, administrators, and researchers without direct student involvement in the design of SFLADs. The primary design criteria of SFLADs is developing interactive and user-friendly interfaces or sophisticated algorithms that analyze the collected data about students' learning activities in various online environments. However, if students are not using these tools, then analytics about students are not useful. In response to this challenge, this study focuses on investigating student perceptions regarding the design of SFLADs aimed at providing ownership over learning. The study adopts an approach to design-based research (DBR; Barab, 2014) called the Integrative Learning Design Framework (ILDF; Bannan-Ritland, 2003). The theoretical conjectures and the definition of student ownership are both framed by Self-determination theory (SDT), including four concepts of academic motivation. There are two parts of the design in this study, including prototypes design and intervention design. They are guided by a general theory-based inference which is student ownership will improve student perceptions of learning in an autonomy-supportive SFLAD context. A semi-structured interview is used to gather student perceptions regarding the design of SFLADs aimed at providing ownership over learning.

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INTRODUCTION

Overview

The relationships between learning, teaching, and technology generate wide-ranging opportunities and challenges for educational research (Collins & Halverson, 2018). Concerning formal education, novel technologies enable many curricula to operate predominantly online. These online curricular platforms present powerful new opportunities. For example, designers can more closely monitor and collect data related to individual decision-making then analyze these decisions to characterize individual learning. These same platforms also introduce new challenges such as how best to utilize new streams of data and information in order to generate useful insights. Efforts to generate, understand, and productively use data from online learning platforms have organized into a field of educational research called Learning Analytics (LA).

LA is a rapidly evolving field of study with no universally agreed upon definition. The Society for Learning Analytics Research loosely defines Learning Analytics as "the measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (Siemens and Gasevic. 2012, p. 1). In relation to online educational environments, LA has been described as "an educational application of web analytics aimed at learner profiling, a process of gathering and analyzing details of individual student interactions in online learning activities" (Johnson et al., 2016, p. 38). By far, the applications of the LA techniques have focused heavily on the identification of students'

learning patterns and the predictions of student-at-risk as well as the accessibility of actionable feedback (Knight and Buckingham Shum, 2017). For instance, Learning Analytics Dashboards (LADs) is one kind of LA application for presenting the information. LADs are intended to support teachers in providing students with useful feedback by using a traffic signal visualization of red/yellow/green lights to indicate whether a student is at the risk of failure, i.e., green means low risk, yellow factors medium risk, red means high risk (Klerkx, Verbert & Duval, 2017). The approach can be beneficial in helping teachers accomplish their pedagogical goals; however, it inevitably increases teacher control and decreases student autonomy (Bodily and Verbert, 2017b). Approaches like this also underscore that less attention has been paid to the needs of students in the design and evaluation of LA applications (Bodily and Verbert, 2017a).

Current Aims

In order to address student needs, LADs have evolved into specialized, student-facing applications called Student-Facing Learning Analytics Dashboards (SFLADs; Teasley, 2017). SFLADs provide learning performance data directly to students. Specifically, SFLADs analyze information traces from learning experiences and present them to students in a digestible form to foster self-regulated and self-directed learning (Kitto, Lupton, Davis, & Waters, 2017; Galaige, Torrisi-Steele, Binnewies, & Wang, 2018). By doing so, SFLADs can enhance students' cognitive abilities to take control of their own learning by helping them utilize information visualizations based on their experiences. To improve metacognition and performance, it may be useful to design SFLADs that recognize and optimize a student's sense of ownership over their learning.

However, the majority of SFLADs report student learning data to teachers, administrators and researchers without direct student involvement in the design of SFLADs (Bodily & Verbert, 2017; Reimers, Neovesky & der Wissenschaften, 2015; Sedrakyan et al., 2017; Galaige et al., 2018). The application of SFLADs faces challenges due to teacher-centered and researcher-centered approaches. Consequently, little is known about evaluating SFLADs aimed at students. In order to comprehensively evaluate SFLADs, developing interactive and user-friendly interfaces or sophisticated algorithms that analyze the collected data about students' learning activities in various online environments are necessary. However, if students are not using these tools, then analytics about students are not useful.

In response to this challenge, this study will focus on investigating student perceptions regarding the design of SFLADs aimed at providing ownership over learning. The questions guiding inquiry are:

1. What is the effect of giving students greater ownership of learning on their perceptions?
2. How does the design of SFLADs influence students' perceived ownership of learning?
3. What is the role of student ownership in the design of SFLADs in relation to student perceptions of SFLADs?

The intellectual merit of this study lies in integrating theoretical perspectives to define student ownership in the realm of SFLADs in order to inform efforts to design SFLADs that will make better use of the affordances of learning technologies in promoting self-determined learning and lifelong learning. To address these research

questions, the study adopts an approach to design-based research (DBR; Barab, 2014) called the Integrative Learning Design Framework (ILDF; Bannan-Ritland, 2003). ILDF encompasses a process model for conducting design research built on the integration of processes from multiple fields, including instructional design, object-oriented software development, product development, and diffusion of innovations and educational research (Bannan-Ritland, 2013). ILDF consists of four interconnected design cycles that organize this study. They are (a) the informed exploration phase; (b) the enactment phase; (c) the local impact evaluation phase; (d) the broad impact evaluation phase (Bannan-Ritland & Baek, 2008). Each cycle is described in more detail in the following chapters. Notably, due to the exploratory and experimental nature of this study, the results of this study are not the final product of an intervention. It is the first step of an iterative design process of prototyping, testing, analyzing, and refining. Therefore, I will not address the broad impact evaluation of the four SFLAD prototypes and their first implementation in this study directly. Instead, I will discuss the conclusion, implication, and limitation of this intervention.

ILDF enables researchers to identify and understand the important factors related to both systems of learning and teaching in various contexts and the relationship between these systems and technology within the design process. It can also help generate knowledge and design principles that will provide rich information on aspects of learning, cognition, expert and novice perspectives, as well as stakeholder positions that inform design and decision-making (Bannan-Ritland, 2013). Due to the exploratory nature of this study, it can be categorized as a development study. A development study is informed by prior research and has a twofold focuses: (a) developing a research-based

intervention as a solution to complex problems (i.e., research-based interventions of design research) and (b) constructing (re-usable) design principles (i.e., the theoretical yields of design research), which sometimes refer to theory building as part of the output as well as practical solutions. (Plomp, 2013; Kennedy-Clark, 2013). My intentions of this design research are well aligned with the affordance of ILDF. Therefore, this study will be conducted following the design phases, as mentioned above.

Organization

This thesis is organized as follows. Chapter 2 (i.e., the informed exploration phase) serves as a synthesis of the relevant literature. I divide this chapter into two sections. In the first section, I discuss a broad research interest that was inspired by a shadow experience in a learning analytics community. In order to narrow down the topic of this design research, I then conduct a systematic and thematic literature review about LA, LADs, and SFLADs, respectively, in this section. I further frame my own definition of student ownership by applying the theory development method in the second section. Mainly, I review three common motivational frameworks for studying students' academic motivation, including self-regulated learning theory, social comparison theory, and self-determination theory. At the end of this section, I propose three initial theoretical conjectures based on a detailed examination of the self-determination theory. Chapter 3 (i.e., the enactment phase) includes the production of the materials for this study and the experimentation process. Chapter 4 (i.e., the local impact evaluation phase) focuses on analyzing the collected data that is generated by the semi-structured interview and self-reported questionnaire during the intervention, as well as discussing the results in terms

of the research questions. Chapter 5 (i.e., conclusions) is where I include the implications of this study that emerge from the three phases as mentioned earlier that might inform the future design of SFLADs.

CHAPTER 2

THE INFORMED EXPLORATION PHASE

As the initial phase of the Integrative Learning Design Framework (ILDF; Bannan-Ritland, 2003), the informed exploration serves as a foundation of the development study for two reasons: (a) it will identify the design directions by identifying the intended audiences for the design and the research gaps in the literature; (b) it will generate the initial theoretical framework and frame the initial theoretical conjectures for the design research. Given the exploratory nature of this design research, the initial explorations into the target audience and related literature of learning analytics (LA) might reveal a plausible path for the design. Drawing on Bannan-Ritland, I described this phase as a two-step sequence: survey literature and theory development.

Survey Literature

The broad design research interest evolved from a direct participation and observation in a data analysis community called Action Lab at Arizona State University's (ASU) EdPlus, where I shadowed and interviewed a data researcher whose research project is to use predictive models to uncover some critical factors that separate students who have the ability to progress in math from those who cannot in the adaptive learning environment of ALEKS (an interactive tutoring system for learning business math). This experience sparked my curiosity to explore the LA field. Then, popular sources related to LA in education ranging from foundational concepts to applications were reviewed (Lang, Siemens, Wise & Gasevic, 2017; Marzouk et al., 2016; Schumache & Ifenthaler, 2018; Papamitsiou & Economides, 2014; Siemens & Baker, 2012). Synthesizing these

resources improved my knowledge in relation to learning analytics techniques in the digital learning context. This effort resulted in the broad research objectives: (a) to investigate the applications of learning analytics and (b) to generate knowledge about the affordance of learning analytics applications in improving the quality and value of the online learning experience. More specifically, a prominent theme emerged across the review of literature, which is one kind of learning analytics application called learning analytics dashboards (LADs; Klerkx, Verbert and Duval, 2017). LADs were widely used among teachers, students, and administrators for providing graphical representations of the learning analytics information in order to facilitate teaching and learning (Verbert, Duval, Klerkx, Govaerts & Santos, 2013**).** Further to this literature review, I gradually narrowed down the theme to one student-facing solution named Student-facing Learning Analytics Dashboards (SFLADs; Teasley, 2017) and identified a common shortcoming in its implementation and evaluation.

Learning analytics. Talking about Learning Analytics (LA; Knight and Buckingham Shum, 2017) is like calling an old friend by a new name. There is a long history of LA in education, and anything that related to reflecting on learners' achievements and patterns of behavior in relation to others can be considered LA (e.g., Statistics). Combing the development of computational and mathematical approaches (e.g., machine learning, social network analysis, data mining, artificial intelligence, content analysis, and adaptive learning, etc.) with the emergence of data-intensive applications to education, learning analytics has been reintroduced as an educational technology and has become a hot topic in the education industry. The International Conference on Learning Analytics (2011) posted a definition of LA: "Learning analytics

is the measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (Siemens and Baker, 2012, p. 252). This definition emphasizes three pivotal elements—data collection, measurement, and action—which endow LA with new flavors in technology-rich settings.

First of all, data collection, the primary and fundamental basis, enable the collected data to be more personal and relevant to individuals with the help of the advanced computational methods. Next, LA assesses learning outcomes objectively, which is an approach that focuses on high-quality formative assessment rather than summative characterizations of learning (e.g., the traditional large-scale summative assessment). One unique feature of formative assessment is that the use of assessment information is a part of the ongoing learning process and integrally connects with the curriculum and instruction that can reflect students' learning progression (Pellegrino, 2014). Consequently, related stakeholders can harness the power of LA to trace every students' path of mastery to make interventions at an individual level. Finally, action, the most distinguished aspect of the definition, reflects the ultimate goal of the LA technique which is optimizing learning and the environments in which it occurs. On the basis of these three new flavors, LA can lend real-time insights into the decision-making process for the related stakeholders by making sense of personal learning information.

Learning analytics dashboards. Such aforementioned fine-grained personal learning activity data that LA collected would demand the tools for the review and analysis of their personal learning history. Dashboard, a tool for monitoring and understanding business at a glance (Few, 2006), was borrowed from the Business

discipline. Also, with the emphasis on the analysis of learning progression as a means to measure what's going on in online learning environments, learning analytics dashboards emanated. As the Learning Analytics Dashboards (LADs) research field is still relatively young, most studies are exploratory and proof-of-concept (Schwendimann et al., 2017). Different definitions for dashboards have been proposed due to its multifaceted nature. For example, researchers have made a distinction between various types of dashboards based on a variety of target audiences, including administrator dashboards, instructor dashboards, and student dashboards (Schwendimann et al., 2017). In this study, I focus on the micro-level of individual learners, which is student dashboards. As its name indicates, student dashboards spring up with the intent of facilitating student learning by collecting, analyzing and visualizing learner history to deliver actionable information (Broos et al., 2017; Charleer et al., 2016).

Student-facing learning analytics dashboards. Student-facing learning analytics dashboards (SFLADs) contrast instructor-facing dashboards (Schwendimann et al., 2017) in which the teacher is the main user monitoring students. SFLADs underscores putting students at the center of dashboard design, use, and evaluation processes (Reimers et al., 2015). In providing LADs directly to students, researchers have recognized that a lack of student involvement in the evaluation of SFLADs is problematic (Bodily et al., 2017; Galaige et al., 2018; Kitto et al., 2017). Even if SFLADs are designed for student uses, these systems restrict student autonomy as administrators and instructors make decisions affecting student learning without direct student involvement (Bodily & Verbert, 2017a). Specifically, Bodily and Verbert (2017a, 2017b) reviewed 93 articles of student-facing learning analytics reporting systems and identified a perceived

shortcoming regarding the evaluation of SFLADs: the lack of focus on student involvement in the evaluation of such reporting systems. They mentioned that most of the studies on the evaluation of SFLADs are from practitioners and researchers' perspectives. They suggested that more researchers should evaluate student perceptions of the effectiveness of SFLADs in terms of the design of SFLADs to support student motivation in the adoption of SFLADs. That said, most popular studies of SFLADs paid no attention to the perceptions of student groups, which can be fatal for the adoption of this student-facing tool.

Theory Development

The usefulness of the theory development method in ILDF is to resolve an informed and productive perspective for developing and validating the initial theoretical conjectures (Edelson, 2002). To this end, this section presents considers motivational frameworks for SFLADs design and a definition of student ownership as key theoretical perspectives informing this study. In turn, it enlists these perspectives to formulate initial theoretical conjectures about the ways that SFLADs mediate metacognition and performance.

Motivational frameworks for SFLADs design. This section builds the necessary framework for my investigation. Apart from the shortcoming above concerning the evaluation of SFLADs, researchers also recognized that there have been little studies that focus on various theoretical frameworks in an online environment other than Self-regulated Learning Theory (SRL; Butler and Winne, 1995) and Social Comparison Theory (Festinger, 1954) (Schwendimann et al., 2017; Jivet, Scheffel, Drachsler &

Specht, 2017; Jivet, Scheffel, Specht & Drachsler, 2018; Teasley, 2017). They suggested that more research that incorporates additional theoretical frameworks into the design of SFLADs to see the effect on student performance and behavior is needed (Bodily and Verbert, 2017a, 2017b; Schwendimann et al., 2017; Jivet et al., 2017). Completing a literature review has offered me many strategies for selecting proper theories. A prominent theory, the Self-Determination Theory (SDT; Deci and Ryan, 2008), caught my attention because it can lend insight into (a) what factors can influence student perceptions of the effectiveness of SFLADs and (b) how we can take such factors into account in the design of SFLADs.

Self-regulated learning theory (SRL) and social comparison theory. One common limitation of SFLADs is that the educational concepts of SFLADs design only involve SRL and social comparison theory (Schwendimann et al., 2017; Jivet et. Al., 2017; Jivet et al., 2018; Teasley, 2017). For example, Jivet and colleagues (2017) conducted a systematic review of 28 papers that described empirical evaluations of SFLADs together with their theoretical frameworks and found that two theories that are applied most commonly in the design of SFLADs are SRL and social comparison theory. Specifically, a significant purpose of SFLADs regarding SRL is providing students with feedback to support awareness and trigger reflection (Jivet et al., 2017). Social comparison theory states that the display of peer performance could motivate students in their awareness, self-reflection, and sense-making on SFLADs (Teasley, 2017). However, there are four phases of SRL, including planning, monitoring, control, and reflection (González-Torres & Torrano, 2008). Current research on SFLADs only focuses on "reflection"; the last phase of SRL, is questioned (Jivet et al., 2017). In particular, SRL is

tied up with student motivation because each phase of the SRL cycle needs students to volitionally use various cognitive strategies to achieve the desired academic results (González-Torres and Torrano, 2008). Therefore, what is the role of student motivation in the SRL? How can we embody the first three phases of the SRL cycle in the design process of SFLADs? These questions make me wonder if SFLADs might have a broader purpose besides fostering awareness and reflection, such as autonomously and strategically directing student motivation towards self-relevant learning goals by increasing the accessibility and readiness of personal data as a means to help students to meet their needs. Furthermore, the researchers found that the motivational impact framed by social comparison theory was mixed (Jivet et al., 2018; Teasley, 2017; Galaige, Torrisi-Steele, Binnewies & Wang, 2018). Some authors found evidence that peer-comparison demotivated and had a detrimental effect on motivation among low-performing students because they tend to experience disappointment and reluctance in learning (Jivet et al., 2018; Lim, Dawson, Joksimovic & Gašević, 2019). In this regard, neither social comparison theory nor SRL alone can evaluate the impact of SFLADs. When it comes to evaluating the theoretical framework of SFLADs, we need to explore how the different educational concepts entwined with and influenced each other.

Self-determination theory (SDT). Various well-established theories have been examined about student academic motivation. I conducted this study through the lens of SDT for the following reason: the traditional dichotomous conceptualization of intrinsic and extrinsic motivation hardly explains student perceptions regarding SFLADs due to the diversity of SFLADs users. Moreover, as a metacognitive tool, SFLADs are focusing on supporting learners' awareness and reflection on their learning activity (Jivet et al.,

2017). Specifically, metacognition is optimal when learners are motivated to explore the new material in order to master certain fields of knowledge (mastery goal orientation; Winne and Azevedo, 2014). Thus, the effectiveness of SFLADs will be ensured when learners are motivated. SDT described the importance of motivation in its definition:

> A macro theory of human motivation addresses such basic issues as personality development, self-regulation, universal psychological needs, life goals and aspirations, energy and vitality, nonconscious processes, the relations of culture to motivation, and the impact of social environments on motivation, affect, behavior, and wellbeing. (p.182)

In the next two subsections, I will discuss the two major concepts within SDT that SDT researchers have explored, including the concepts of goal contexts (i.e., autonomy-supportive environments versus controlling social environments) and the concepts of goal contents (i.e., intrinsic versus extrinsic personal goals) (Vansteenkiste, Lens and Deci, 2006). The former focuses on what social context is related to learning; the latter focuses on what content of the goals people pursue.

Goal contexts: autonomy-supportive environments versus controlling social environments. This section distinguishes two types of goal contexts theorized in SDT and considers how they might inform SFLADs designs to improve student motivation in relation to self-reflection and self-awareness and the overall effectiveness of SFLADs. To begin, Vansteenkiste and colleagues (2006) proposed a definition for autonomy-supportive environments based on Deci and colleagues' description of this concept. The first type of goal context, autonomy-supportive environments, was defined as follows:

> Instructors empathize with the learner's perspective, allow opportunities for self-initiation and choice, provide a meaningful rationale if choice is constrained, refrain from the use of pressures and contingencies to motivate behavior, and provide timely positive feedback (Vansteenkiste et al., 2006, p.21).

Contrastingly, they conclude that the second type—controlling social environments—tends to overly pressurize individuals into engaging in the learning by placing them under pressure, such as setting deadlines, using the controlling language (e.g., "have to," "should" and "ought"). In particular, they emphasized the unique role of autonomous motivation in SDT. Autonomous motivation is where choices originate with the learners. They further proposed a motivational mediation model indicating that a positive association between the autonomy-supportive environments and learning outcomes (e.g., deep-level learning, greater achievement, and higher persistence at learning activities), is mediated by autonomous motivation (See Figure 2). SFLAD designs may benefit from thoughtful consideration of the concept of autonomous-supportive environments. Specifically, it can lend insight into how SFLADs design supports the learners' autonomy with respect to their online learning activities. That is, SFLADs design should effectively support learners' free-choice in their learning activities by making the acceptability and trustworthiness of personal informatics achievable for learners. For example, students are afforded a level of confidence to make a decision about whether or not they should withdraw from a course based on the visual analytics for their learning history on the SFLADs (e.g., time spent, course completion, self-test results, system recommendations, self-comparison, and instructors' feedback, etc.). Consequently, based on the benefits of the autonomy-supportive contexts (e.g.,

promoting autonomous motivation, academic competence, school achievement, and well-being) on students' motivation (Vansteenkiste et al., 2006), I hypothesize that students' perceptions about learning on an SFLAD could be improved if their free-choice learning is warranted on the SFLAD because this free-choice learning might lead to a higher autonomy motivation.

Goal contents: intrinsic versus extrinsic goal framing. Similarly, SDT differentiated two types of goal contents. It contrasts intrinsic goal framing (e.g., personal growth, meaningful relationships with others, becoming more healthy and fit, or contributing to their community) from extrinsic goal framing (e.g., fame, financial success, and physical appearance) with respect to student engagement in the learning activity and student academic performance (Vansteenkiste et al., 2006). Most SDT studies indicated that intrinsic goal framing in an autonomy-supportive condition led to higher autonomous motivation, better test performance, and greater persistence than in the controlling context (Vansteenkiste et al., 2006). Likewise, SDT studies (Vansteenkiste et al., 2006) maintain another motivational mediation model regarding goal contexts, as demonstrated in Figure 1. It is proposed that autonomous motivation also mediates the predictive effect of goal contents on learning outcomes. Therefore, I hypothesize that students' perceptions about learning on an SFLAD could also be improved if the learning activities are well aligned with their intrinsic learning goals on the SFLAD because such self-relevance and meaningfulness might lead to a higher autonomy motivation.

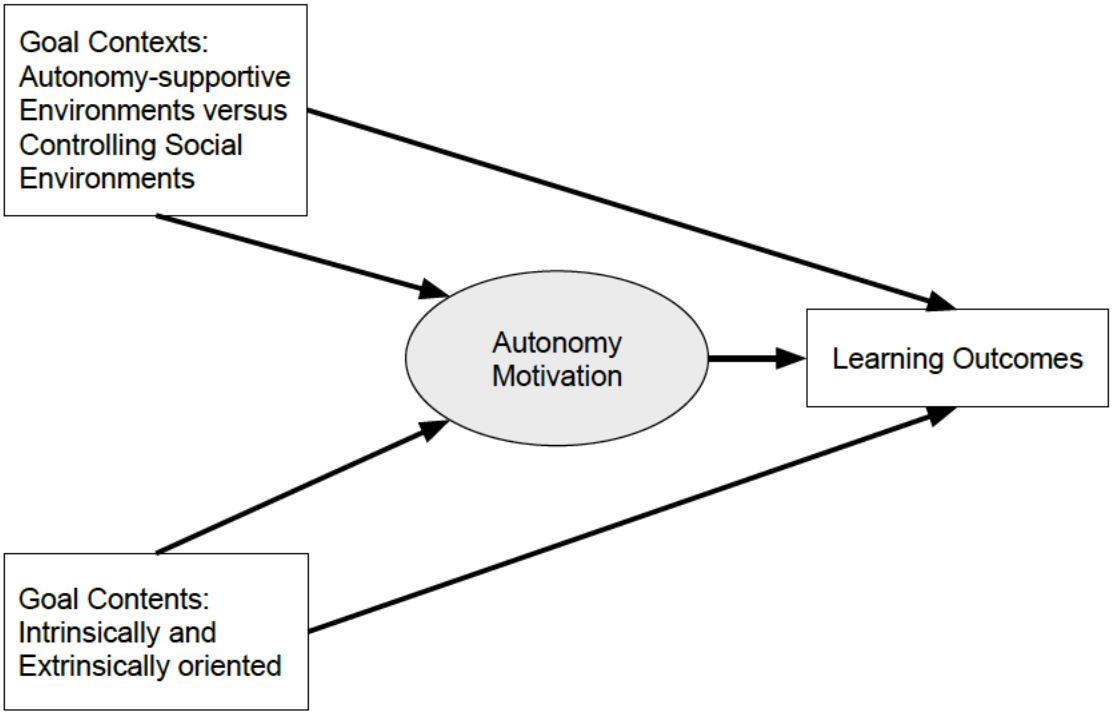

Figure 1. Motivational Mediation Model

The Definition of Student Ownership. Incorporating the two hypotheses above, I will use the term "*Student Ownership*" here to connote a condition where students can be afforded both free-choice learning and intrinsic goal framing opportunity on SFLADs. I choose this term over others that express a similar meaning such as student agency and student autonomy for the reason of emphasizing a sense of control to make learning decisions that are most relevant to users' intrinsic goals by understanding and utilizing SFLADs. Since SDT frames this study, the definition of student ownership is heavily influenced by this theory. Particularly, I synthesized two major concepts of SDT to define student ownership with a twofold conception: a) the freedom of choice that students have regarding their own learning activities and learning trajectories and b) the opportunity of identifying the relevance of meaningful information visualization that is consistent with

their intrinsic goals (i.e., high perceived self-relevance). My purpose of emphasizing the role of student ownership in the design of SFLADs is in line with what autonomous motivation and intrinsic goals have demonstrated in the effectiveness of performance and the positiveness of psychological and behavioral outcomes (e.g., promoting awareness and reflective examination of needs) (Deci and Ryan, 2008). Specifically, my purpose is to help students become autonomous data-informed learners, fostering, and actively supporting data-informed decision making in their own learning activities. In short, student ownership is afforded by SFLADs in the fashion of empowering students to volitionally select self-relevant objectives based on their understanding of information visualization displayed on the SFLADs.

The Theoretical Conjectures. This design research was framed by SDT and aims at investigating the role of student ownership in the design of SFLADs in relation to student perceptions. Also, I proposed a student ownership mediation model. As shown in Figure 2, the first conjecture is that student ownership corresponds with student perceptions. Second, the SFLADs design features in this study can promote student ownership. Third, the SFLADs design features in this study can positively predict student perceptions, and this effect is mediated by student ownership. Correspondingly, my research questions are: 1) What is the effect of giving students greater ownership of learning on their perceptions? 2) How does the design of SFLADs influence students' perceived ownership of learning? 3) What is the role of student ownership in the design of SFLADs in relation to student perceptions of SFLADs?

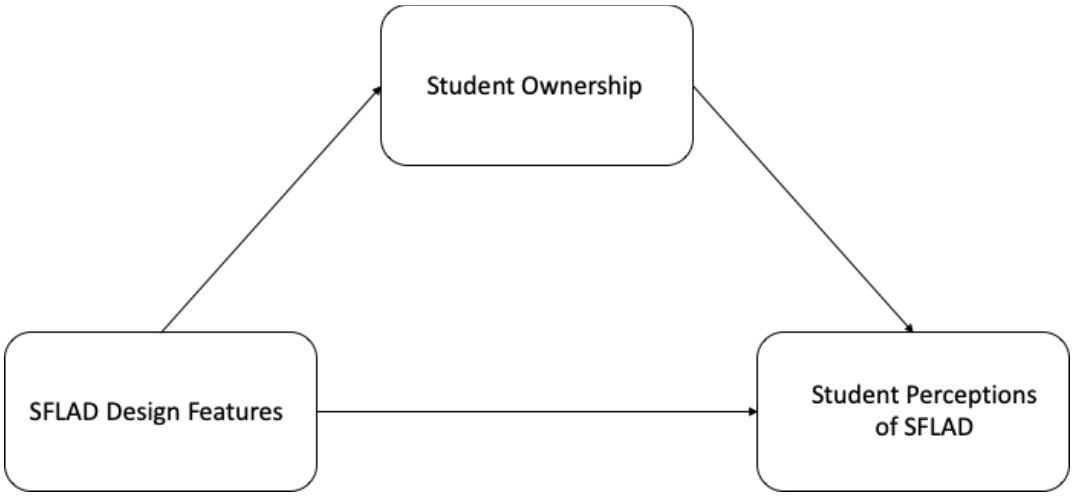

Figure 2. Student Ownership Mediation Model

CHAPTER 3

THE ENACTMENT PHASE

After grounding the theoretical framework for this study in SDT and solidifying the three theoretical conjectures in the informed exploration phase, the enactment phase translates the three theoretical conjectures into the design of prototypes and intervention to investigate student perceptions of SFLADs design that provide them with greater ownership of learning. Moreover, in order to explicitly and concretely embody the theoretical conjectures in the prototypes design and intervention design, I drew upon Sandoval's (2014) technique for conceptualizing design research called conjecture mapping. This technique is "a means of specifying theoretically salient features of a learning environment design and mapping out how they are predicted to work together to produce desired outcomes" (p.19). Similarly, the general theory-based inference of this study is that student ownership (based on SDT) will improve student perceptions of learning in an autonomy-supportive SFLAD context. However, how should I design the salient features of the SFLAD prototypes that will embody the concept of student ownership? How should I design the intervention that allows me to specify the relationship between the prototype design and the theoretical conjectures to yield desired outcomes (e.g., the positive student perceptions of the proposed SFLADs)? These concerns mentioned above about how embodied elements of the design were generated can be articulated as design conjectures (Sandoval, 2014). I will discuss how I map out the design conjectures for this study in more detail in the following sections.

In addition, a mixed-methods approach that combines qualitative and quantitative techniques (e.g., semi-structured interview and questionnaires) will be conducted to

collect the data regarding their perceptions in three subscales (e.g., perceived usefulness and ease of use, perceived behavior change, and perceived skills change) (Aguilar, 2016). This enacted design phase provides opportunities for construction and examination of the paper-based prototypes with several audiences prior to the more time-intensive computer-based production.

Participants

This study involves five adult participants. To gain diverse perspectives on the evaluation of SFLADs, there is no gender or demographic requirement in this study. This study will take place in a hypothetical setting. Participants need to think about an online course that they are taking or have taken within one year to ensure their responses to be contextualized in a manner, and then keep the course in mind for the duration of the interview. In this situation, the participants who have experienced the online courses in a relatively recently would be most likely to resonate with their online learning experiences. The final sample consists of three females and two males, thereinto, two White and three Asian, the age range from 23 to 52 (e.g., 23, 27, 27, 52, 52), and the education level of all five participants is postgraduate education.

Prototypes Design

According to Sandoval's (2014) general conjecture map for educational design research, the design conjectures are unfolded through two steps in sequence, including embodiment and mediating processes. The set of design conjectures is mapped in Figure 3. The high-level theory-based inference guiding the whole design was derived from my observation and experience in a learning analytics community (e.g., Action Lab) as well

as the identification of research gaps. Specifically, the embodiment is a reification of the high-level theoretical conjectures. Due to the complexity and uncertainty in the design of the learning environment, the embodiment includes a wide range of features that are related to the design learning environment (e.g., tools/materials, task and participant structures, and discursive practices). The mediating processes refer to the link between the embodiment and the desired outcomes. Sandoval (2014) gave us an example of this process: “the use of particular tools for specific tasks enacted in specific ways is intended to produce certain kinds of activity and interaction that are hypothesized to produce intended outcomes” (p.23). Thus, in this study, the embodiment will include prototype design and intervention design, respectively, because these two procedures together serve as the tool and the task and participant structures that embody the three theoretical conjectures. Also, the mediating processes of this study will focus on connecting the salient design features from prototype design and the materials/activities from intervention design to the desired outcomes. First, I will design four different SFLAD porotypes that are framed by four concepts within SDT. For example**,** Figure 3 shows the visual display used in SFLAD#1, which is framed by the concept of controlling social environment in SDT. Then, I will articulate the mediating process of each prototype by justifying the process–outcome link of design features to desired outcomes therein.

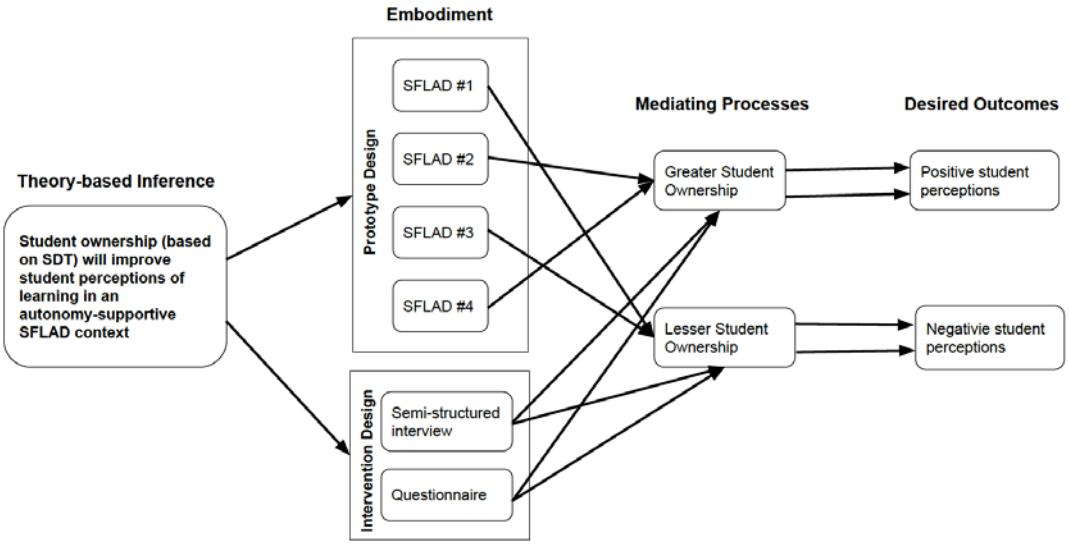

Figure 3. Design Conjecture Map for Investigating Student Ownership

All four SFLADs were designed to demonstrate students' hypothetical information visualization in an online course they were asked to recall. Paper prototyping is an essential step in user interface and user experience design to get quick feedback and minimize costs in the computer-based design process (Santos, Govaerts, Verbert, and Duval, 2012). Common visualization types such as Line graphs, Stacked bar charts, Network graphs, and Scatterplots will be used to visualize student's hypothetical information visualization. The affordances of these three types of graphs are as follow:

1. Line graph: line graphs can depict linear relationships between two or more variables at a glance to help audiences quickly grasp the necessary information (e.g., upward or downward trends).
2. Stacked bar chart: stacked bar chart directly translates the numerical values into a graphic form that stands out as the different colored cells to help audiences capture the important information efficiently (Heiberger & Robbins, 2014).

3. Network graph: network graphs can inform the learning design of self-guided digital learning experiences because the nodes of the network graph can help users identify patterns within the online learning environment by giving them a position in a two-dimensional (2D) plane as a network (Ifenthaler, Gibson & Dobozy, 2018).
4. Scatterplot: as the first true 2D graphics form, the form of the scatterplots allows these higher-level visual relationships to be spotted easily at first glance. For instance, one can add additional visual annotations (reference lines, curves, enclosing contours, etc.) to make those relationships more visible (Friendly & Denis, 2005).

The four SFLAD prototypes are:

1. SFLAD#1: Controlling social environment (see Figure 4). This SFLAD is framed by the concept of the controlling social environment within SDT. Its data sources embody the external forces, such as awarding the digital badges to learners after task completion. Its design conjecture is that the digital badges will not promote student ownership and lead to positive student perceptions because students hardly stay motivated and constrain persistence in learning under pressure.

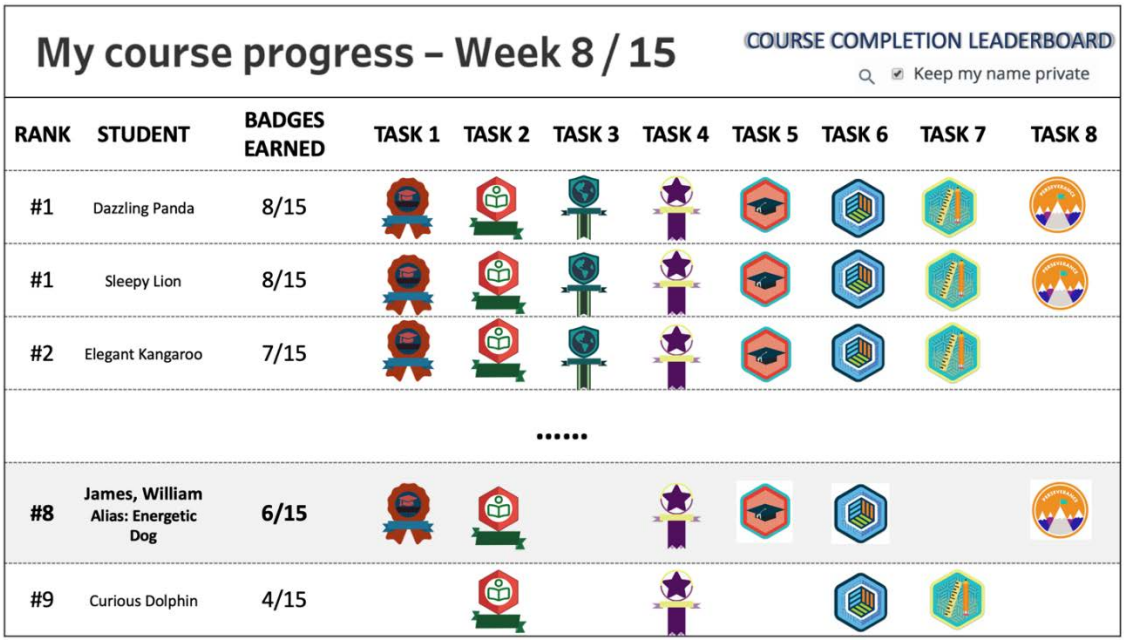

Figure 4. Example of SFLAD Prototype (SFLAD#1, Controlling Social Environment)

2. SFLAD#2: Autonomy-supportive context (see Figure 5). This SFLAD is framed by the concept of the autonomy-supportive context within SDT. Correspondingly, the data sources primarily include the teachers' informatics, such as teachers' reference (i.e., a line graph shows the time spent on their courses; a network graph shows the interaction with students in). The design conjecture of this prototype is that teachers' informatics will promote student ownership and lead to positive student perceptions because students are afforded more information to support their data-informed decision-making in their own learning trajectory. For example, students who choose to enroll in teacher 3' course is because his/her time-spent on different activities is above average (see Figure 5-line graph). Also, the performance evaluation history indicated that he/she is more likely to provide useful feedback and be accessible to students (see Figure 5-network graph), which also explain why

he/she spent most of the time on discussion forums (e.g., providing students with useful feedback about their posts or answering students' questions). This teacher's informatics helps students become data-informed learners.

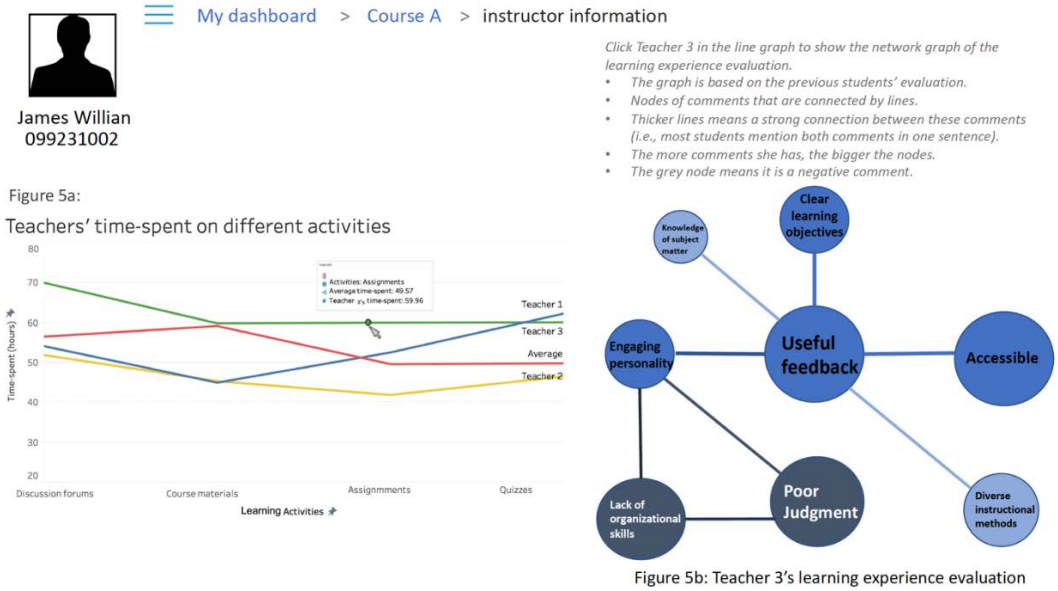

Figure 5. Example of SFLAD Prototype (SFLAD#2, Autonomy-supportive Context)

3. SFLAD#3: Extrinsic goal framing (see Figure 6). As the opposite of intrinsic goal framing, the data sources of this SFLAD include peer-referenced information and deadlines of the task. The design conjuncture of this prototype is that peer-reference framework will not promote student ownership and lead to positive student perceptions because students won't be motivated by the information to take any form of action if they don't perceive a self-relevance of such information. For example, comparing the time-spent ratio of a weekly task to the cohort won't motivate him/her to change his/her learning behavior and skills (see Figure 6- Stacked bar). Apart from having a general idea of his/her time-spent ratio of weekly task in the cohort, he/she can further have knowledge of whether he/she studied effectively and

efficiently in his/her cohort by visualizing the distribution of his/her data points of time-spent and task scores on each week in the Scatterplot in Figure 6. Particularly, the peer-reference line divides his/her results into four quadrants. For instance, Q1 indicates the less time-spent with the higher task scores. Contrastingly, Q3 indicates more time-spent with the lower task scores. As the scatterplot in Figure 6 shows, he/she is less effective and efficient in studying this course compared to his/her peers due to the most of his/her data points are in the Q2 and Q3.

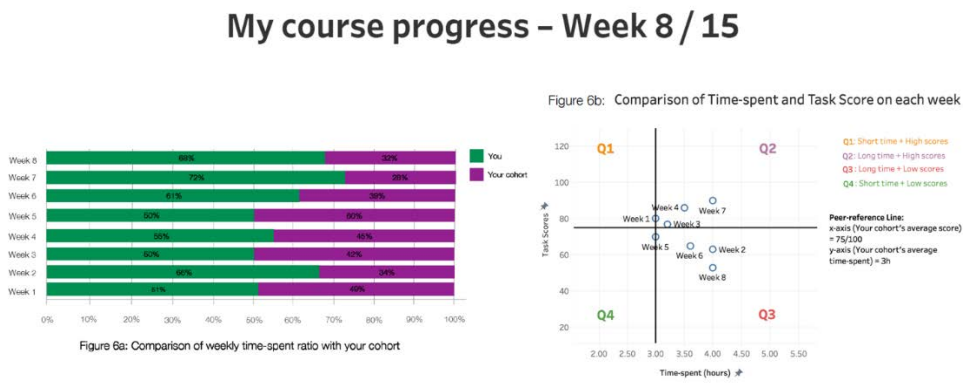

Figure 6. Example of SFLAD Prototype (SFLAD#3, Extrinsic Goal Framing)

4. SFLAD#4: Intrinsic goal framing (see Figure 7). This SFLAD is framed by the intrinsic goals framing within SDT. Then, the data sources focus on displaying personal growth instead of external rewards or peer comparisons, such as proving students with self-relevant information to facilitate their self-monitoring and self-evaluation on learning outcomes. The design conjecture of this prototype is that the self-reference framework will promote student ownership and lead to positive perception. For example, unlike SFLAD#3 that underlines the extrinsic goal framing, the Stacked bar chart, as shown in

Figure 7, majorly focuses on presenting the learner's personal growth. He/she can find the most time-consuming learning activities in the past eight weeks because this chart portrayed the weekly time-spent on four different learning activities. This information allows he/she to reflect on why he/she spent more time on certain learning activities than others. However, looking his/her distribution of the time-spent and task scores (see Figure 7-Scatterplot), we can see his/her learning outcomes is quite average because: (a) almost half of his/her data points are located in the Q3 (3/8) and (b) another two tasks are in Q2 and Q4 which indicates that the more (less) time he/she spends on the tasks, the higher (lower) score he/she can get, which is less effective and efficient. Notably, this scatterplot is as the same as in SFLAD#3. The only difference is instead of using a peer-reference line, and it uses a self-reference line (e.g., his/her average time-spent and average task score) to underscore the self-assessment of learning outcomes. Combining the information in the Stacked bar chart in Figure 7, he/she can infer that focusing on learning courses materials (e.g., watching lecture videos and reading articles) might not be the best way to learn this course. Instead, the interaction and collaboration with peers in the discussion forum could play a key role in learning this course because the other two activities are almost evenly distributed. This self-comparison information will support relatedness and motivate students' to be autonomous and accountable for decisions made and actions taken (e.g., withdrawing from the course or improving his/her learning skills).

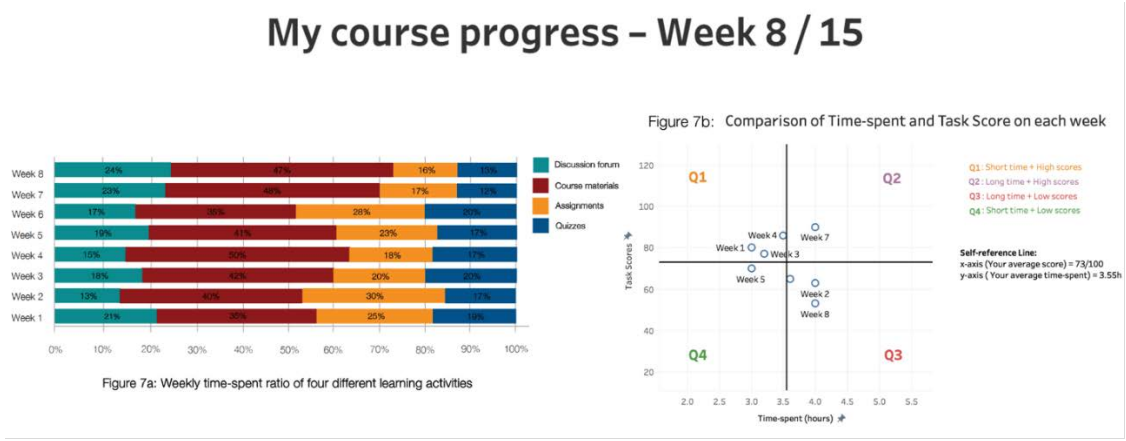

Figure 7. Example of SFLAD Prototype (SFLAD#4, Intrinsic Goal Framing)

Intervention Design

Participants will be asked to examine four SFLAD prototypes that depicted their hypothetical course progress (e.g., week 8 of a 15-week academic term at Arizona State University). Each prototype will be printed on a separate sheet of paper. Participants will be interviewed during the examination of the prototypes by a semi-structured interview containing the open-ended questions related to how students evaluate the SFLAD prototypes. The questions are designed to capture student perceptions of the proposed SFLADs in order to validate the three theoretical conjectures that were framed by SDT and the corresponding design conjectures.

Drawing upon Aguilar's interview protocol (2016), I design a protocol for this study (describe below) which focuses on student perceptions as it relates to student ownership, and also enabled the development of an a priori coding scheme framed by SDT (See Appendix A). The semi-structured interviews will be recorded, transcribed, and analyzed. Also, it is organized into five sets: (a) level of familiarity of the SFLADs; (b) the effect of student ownership on their perceptions; (c) identifying design features that

embody student ownership; (d) student perceptions of these features and (e) overall evaluation regarding SFLADs design.

Set 1: level of familiarity of the SFLADs. At the beginning of the interview, all participants will be asked about the basic questions (e.g., question 1 to question 5) about their experience with the dashboard to get the information of their familiarity with this tool. This question assesses the penetration rate of this student-facing application.

Set 2: the effect of student ownership on their perceptions. The purpose of this section is to capture how much participants value the sense of ownership in an online learning environment. And to what extent will this ownership affect their perceived learning outcomes? The questions (e.g., question 6 to question 8) are included to ensure that participants have an understanding of student ownership. Notably, question 21 and question 22 are used to examine student perceptions about the four SFLAD prototypes after understanding the definition of student ownership in this study. Specifically, the purpose of these two questions is to test if these SFLAD prototypes that embody student ownership will be perceived as more helpful and meaningful than those SFLAD prototypes that are framed by the contrary to the concepts of student ownership.

Set 3: emotional reactions to the SFLAD prototypes that embody student ownership. This section of the interview will begin by asking participants to recall an online course that they are taking or have taken within one year, and then keep that course in mind while they examined subsequent SFLAD prototypes. This process will contextualize the interview in a manner because the participants might come from different disciplines with different learning experiences. A designated course might reduce the relatedness of their prior learning experience in this study. Once participants

have a course in mind, they will be presented with one of four SFLAD prototypes to examine and ask questions (e.g., question 9 to question 20) intended to assess student stated emotional reactions to specific graphical representations that related to student ownership (e.g., I like this graphs).

Set 4: student perceptions. Participants will be asked questions aimed at capturing their perceptions of the SFLAD prototypes around the following three dimensions that are extracted from Bodily and Verbert's (2017) measurement of student perceptions (p.409, Table 5):

1. *perceived usefulness and ease of use* means asking students about the usefulness and easiness of the system. Specifically, to measure the perceived usefulness and ease of use, a well-established Perceived Usefulness and Ease of Use (PUEU) questionnaire from Davis (1989) will be adapted and applied (See Appendix B). No changes will be made other than changes in wording to fit the specific SFLADs studied in this thesis. The questionnaire will be divided into two parts.
2. *perceived behavior changes* mean asking students (e.g., question 23) if they perceived any learning behavior changes (e.g., increasing usage frequency of the SFLADs).
3. *perceived skill changes* mean asking students (e.g., question 24) if they perceived any skill changes (e.g., self-evaluation, self-regulation, and goal setting).

Set 5: overall design features evaluation. Participants will be asked to evaluate four SFLAD prototypes and compare them to one another. Specifically, they will be

asked if the features independently or combinedly in any of the SFLADs are particularly useful, or particularly useless. The final question of the interview asked students to give their suggestions for SFLADs design and explain the rationale for their suggestions.

CHAPTER 4

THE LOCAL IMPACT EVALUATION PHASE

In the Integrative Learning Design Framework (ILDF; Bannan-Ritland, 2003), evaluation is a sequential, two-stage phenomenon, including the local impact stage and the broader impact stage. Due to the exploratory nature of this study, I focus on local impact, which is to investigate how well the designed intervention—the four SFLAD prototypes design and intervention design—satisfy its theoretical conjectures? Local impact evaluation encompasses two aspects: (a) iterative data collection and analysis and (b) refinement of designed intervention and design decisions based on the data collected and analyzed. Notably, this phase might result in revisiting the enactment phase. As a preliminary evaluation, the goal of the local impact stage is to revise and improve the theoretical model embedded in the design. Drawing from the semi-structured interviews and participants' self-reported questionnaire data, I elaborate on these findings in the following sections.

Coding Interview Data

I coded data relevant to a particular point in order to generate evidence about my theoretical conjectures. Specifically, coding serves to document my understanding of the data and how coding transforms my perspective on data and contributes to the construction of the research without precluding someone else from approaching the data in a different way for different purposes. It involves the researcher's subjectivity in relation to the data through which data are interpreted (Smagorinsky, 2008). In this study, I formulated three research questions and a corresponding mediation model called the

Student Ownership Mediation Model (See Figure 2). They are: (a) What is the effect of giving students greater ownership of learning on their perceptions? (b) How does the design of SFLADs influence students' perceived ownership of learning? And (c) What is the role of student ownership in the design of SFLADs in relation to student perceptions of SFLADs? To make sense of the data and justify the research questions I posed for this study, I first need to manifest the relationship between the three essential conceptions that are mentioned in the research questions, including student ownership, SFLADs design features, and student perception. Thus, I use these three conceptions as the themes to categorize the data while coming up with the coding scheme. Specifically, as for the student ownership, I adopt the two layers of meaning in the definition of student ownership as the codes (e.g., "free-choice learning" or "self-relevance"). I then code the student perceptions as "perceived learning behavior change" or "perceived learning skills change," following the interview protocol. Lastly, since this study is framed by four concepts featured in Self-Determination Theory (SDT; Deci and Ryan, 2008), an a priori coding scheme was developed utilizing these four concepts as the primary codes (See Table 1). Correspondingly, four primary codes based on the interview were given four codes that parallel the SDT concepts of autonomy-supportive contexts, controlling social contexts, intrinsic goal framing, and extrinsic goal framing. Also, students' emotional reactions to the SFLAD prototypes design are coded as "positive" or "negative" (See Table 1).

Table 1.

Coding Scheme by Theme with the Interview Examples for Each Code

Theme	*Code*	*Interview examples*
Student Ownership	Free-choice Learning (FL)	"I can tell from looking. I think as far as the one that would help me the most to make decisions about what I'm doing would be this one. Number 4."
	Self-relevance (SR)	"I like three, I think three is relevant, it gives me a good picture of comparison."
Student Perceptions	Perceived Learning Behavior Change (PLB)	"Well, definitely the first instructor evaluation in being able to first pick a good course and then second I like all the badges. And that I would love to click on there, okay, okay, that's motivated to see that blank space, I've got to fill that up and improve my rank."
	Perceived Learning Skills Change (PLS)	"I think number four, also. I think it would drive me, maybe, to look at how I am applying what I am learning in my discussion forums, or how I am applying what I am learning in the assignments."
SFLADs Design Features	Autonomy-supportive Contexts (AC)	"I can choose which teacher I want. I can choose the instructor of the course from those three options and see how well they do on each of these... on the times they spend and also based on previous student feedback; I can decide whether or not this teacher is a fit for my learning style."
	Controlling Social Contexts (CS)	"I don't have as many badges as some other people" "I think it's like a game. Whenever I try to see things like this, I'm kind of like assertive, so I want to get every badge, it keeps me motivated" "Oh, I love how they have the rankings. I love knowing where I am in class. And how I'm doing. And I love these badges. That is really cool."
	Intrinsic Goal Framing (IG)	"that one would be the most helpful for me to make decisions because it shows me whether the time I am spending on different activities is resulting in better scores for the week. And so that's, I want to score as well as possible, regardless of what my peers are doing." "Being able to have some perspective on

		whether I'm spending a lot of time on the assignments, or on the discussion forums, and then seeing how that's resulting in how I'm performing would be useful."
	Extrinsic Goal Framing (EG)	"It would be really interesting to know how much time I'm spending compared to my cohort so that on the left is something that jumps out at me."
Emotional Reactions to the SFLAD Prototypes	Positive Emotion (PE)	"I would love to have something like that." "I like the left graph because it's very straightforward." "It's very black and white. You can tell if you have completed the tasks. I can't tell if I've completed them well or not, just that I have definitely completed them. I can also tell very quickly where I am compared to my fellow students if I'm keeping up or not keeping up."
	Negative Emotion (NE)	"I don't like that as much. The performance evaluation, I'd rather see a line graph." " I think I'm not particularly interested in this bar, like the ratio graph. Like, it doesn't give me like ... I don't want to know how much time the other students went on that. As long as I do it, like, that's the main thing I would focus. I wouldn't want to spend like more on this. "

Drawing on the interview codes as well as statistical analyses of survey data, the remainder of the chapter is organized into three sections: the level of familiarity of SFLADs, the answers to the research questions, and participants' evaluation and suggestions of SFLADs design.

Level of Familiarity with SFLADs

At the beginning of the interview, I asked a set of questions (e.g., from question 1 to question 5) about the use frequency of their own dashboards and their understanding of SFLADs, to examine the penetration rate of this student-facing application. The options

for answering the use frequency include several times a day; about once a day; 2 or 3 times a week, about once a week. Three participants chose “two or three times a week.” One participant’s level of interaction with her dashboard reached “several times a day.” The last participant is about “once a day.” However, when the questions come to SFLAD, unsurprisingly, none of the five participants had heard about it. For example, two participants assume that SFLADs are learning management systems like Blackboard and Canvas. After I explained to them what SFLADs are, they all agree with the idea that is their current dashboards are nothing more than a panel of summery, only depicting their grades and learning materials without placing them in the center of its use. But they all express a great interest in discovering the possibility of SFLADs. It is not surprising that all participants know the dashboard. Learning analytics dashboards (LADs) have gained a significant amount of attention both in researching and application regarding improving cognitive, behavioral, and emotional competencies (Jivet et al., 2017). However, they have never heard about and experienced any SFLADs in online learning. This fact has had me realized that there is a noticeable gap between the education theory and the learning technologies. One propose of this study is trying to seek ways to bridge the gap between the theory and practice of evolutionary techniques for solving large-scale educational problems.

Answers to the Research Questions

I delineate this section from three points based on the research questions. First, to address the first question on exploring the effect of giving students greater ownership of learning on their perceptions, I code the transcription from question 6 and question 7 by using two codes in the student ownership (e.g., FL and SR) and two codes in the student

perceptions (e.g., PLB and PLS). In question 6, I asked them to define “student ownership.” All five participants agree that it related to a sense of control about their own learning. After I informed them of the two layers of meaning of its definition in this study. I told them to reflect on whether they were afforded such student ownership in their online learning experiences. Based on their responses, none experienced student ownership as it was defined in this study. One participant complaints about her current dashboard being confusing and not easy to use. “It forces me to figure out how to use it instead of telling me here's how to use it.” Interestingly, another four participants expressed their complaints on the lack of analytic feature. “Because the analytic part... it doesn't seem like it's telling me much other than just reporting specific data that I already know exists, such as grades.” “I don't see any feedback, it's mostly... like syllabus, things that what I have to do, what I need to do. It's not about the things I have done.” “they use some statistics like the average, or like the mean and something like that, so apart from that I don't see any other things.” Notedly, the usability of the dashboard and the need for accessing the analytics information are the primary concerns that come from the participant when I refer to the term “student ownership.” This result shows that students valued their learning experiences as they interact with the online learning platform. A SFLAD design should not only focus on creating a well-designed learning product/tool Instead, an learning experience is what designers should pay attention to. The SFLAD, indeed, is a learning tool, but it also heavily involved with learners’ experience when it is in use. Then, how do I take students’ experience into account when I design an SFLAD that can meet the challenge of the discrepancy of age and gender, the different level of understanding, even personality?

Secondly, to answer the second research question about whether and in what way the design of SFLADs influence students' perceived ownership of learning, two codes in the emotional reactions to the SFLAD prototypes (e.g., PE and NE) and four codes in SFLADs design features (e.g., AC, CC, IG, and EG) were adopted to code the transcription from question 6 to question 22. The reason that I designated the emotional reactions codes to explore participants' perceived ownership of learning is that it is quite abstract to quantify or qualify the sense of ownership. It has a broad meaning, even in the same context. I don't conduct any comprehensive psychology scales to measure that. I frequently received the emotional reactions to specific SFLAD prototype or feature. Therefore, I focus on documenting participants' emotional responses to the two proposed SFLADs that I intentionally design for representing student ownership so that I can compare them with two others proposed SFLADs that indicate a low level of student ownership. The results are quite surprising in that four participants are actually like the SFLADs with the low level of student ownership. They express a great interest in SFLAD #1 (See Figure 4) and SFLAD #3 (See Figure 6). These two are embodying the two concepts within SDT that propose students are usually less motivated by the external forces (e.g., a leaderboard) and extrinsic goal framing (peer-comparison). Almost five participants expect to have a combination of extrinsic and intrinsic goal framing, such as they would like to have a gamified leaderboard with the information containing both their own detailed learning progression and the peer-reference. They think that such a combination will greatly help them to evaluate their own performance and also motive them to learn. One said, "my favorite is number one. With the badges, to get a quick picture of where I am and what I need to do. And I like seeing the positive reinforcement

with the colorful badges. I like that. I like that a lot." Other two both mentioned that the peer-reference help them figure out where they are at as a whole, and they don't think a solo self-reference would have made any substantial contributions to their judgment of their performance. One indicated, "For me, it's not that clear how I am doing exactly. So what does it mean when I see the average of 73% and what does it mean that I spend 3.55 hours per week? I don't know where I'm at in this class right now. Right now, from what I can see, okay, like... the more time I spend, the less score I get probably." This reaction is unexpecting but also reasonable. Since online learning is distributed learning, people are not physically staying in one place at the same time. In the traditional classroom, people are easy to make a comparison with one another and getting a sense of who is better. However, the internet rules out the possibility of this kind of social interaction. When you learn in front of your computer, you might get curious about how other people are doing. I wondered if it was because these participants who like peer-comparison are Asian. Typically, Asians are more competitive and judgmental. So, they might have a tendency of competing and comparing. However, one of the White female participants told me, "Again, my favorite is number one. With the badges, to get a quick picture of where I am and what I need to do. And I like seeing the positive reinforcement with the colorful badges. I like that. I like that a lot." Except for the personality factor, which is someone maybe inherently more competitive than others, what else does this phenomenon mean? I believe that social perspectives are as critical as any instructional or pedagogical theories. A good learning experience design of the SFLADs in improving the student's perceived ownership of learning is a fruit of the distributed collaboration (David, 2004). Most importantly, the users and their needs should be placed in the center of the collaboration.

Third, in responding to the third research question on the role of student ownership in the design of SFLADs in relation to student perceptions of SFLADs, two codes in the student ownership, four codes in the SFLADs design features, and two codes in the student perceptions were applied to the whole interview transcription. Specifically, student perceptions regarding the four prototypes were gained from three different dimensions. In this study, I access whether there are any differences regarding the perceived usefulness and perceived ease of use about the four prototypes using the Perceived Usefulness and Ease of Use survey scales. Each has six questions with a seven-point Likert-type scale from 1 (strongly disagree) to 7 (strongly agree). Due to the small sample size, I conducted a non-parametric test called Friedman's test, which is used for repeated measures at the ordinal level with small sample size (Bewick & Ball, 2004). There were no statistically significant differences in perceived usefulness between the four prototypes, $\chi^2(3) = 4.56$, $p = .21$. Also, there were no statistically significant differences in perceived ease of use between the four prototypes, $\chi^2(3) = 2.13$, $p = .55$. Table 2 and 3 present descriptive statistics for the Perceived Usefulness and Perceived Ease of Use scales, respectively. SFLAD#1 scores the highest among others in two questionnaires (e.g., 4.93 out of 7; 6.10 out of 7), indicating it is the most useful and easy to use. On the other hand, SFLAD#2 scores the lowest in perceived usefulness, meaning it was recognized as least useful. This result is in accordance with the interview data. All five participants had complained about that the design of SFLAD#2 wrapped in an incomprehensible jargon design (e.g., network graph). Their responses are entirely unexpected. SFLAD#2 is an embodiment of autonomous-supportive context within SDT. I intend to design a piece of information that severs as a supporter to help students make

an autonomous data-informed decision because of the inaccessibility of teachers' information. However, the result did not come out as expected. I think it mostly because the network graph seems to be too befuddled for the participants at first glance. More explanations or cognitive effort are demanded to comprehend the network graph. Unlike the SFLAD#1, the leaderboard with the digital badges, the cognitive overload that is caused by SFLAD#2 could be a significant reason for people's least interest. It motivates me to rethink about the ways of integrating theories into design practice and transferring incomprehensible jargon into an intuitive design.

Table 2

Descriptive Statistics of Perceived Usefulness Survey Scale

Design	*M*	*SD*
SFLAD#1_Usefulness	4.93	1.13
SFLAD#2_Usefulness	3.30	1.65
SFLAD#3_Usefulness	4.47	.52
SFLAD#4_Usefulness	4.70	1.06

Table 3

Descriptive Statistics of Perceived Ease of Use Survey Scale

Design	*M*	*SD*
SFLAD#1_Ease of Use	6.10	.65
SFLAD#2_Ease of Use	5.47	.65
SFLAD#3_Ease of Use	5.27	.56
SFLAD#4_Ease of Use	5.40	.92

Participants' Evaluation and Suggestions of SFLADs Design

One prominent advantage of design-based research is allowing any intervention to be systematically articulated and revised over a number of cycles rather than a single problem-solving process (Bannan-Ritland, 2003). During the intervention of this study, I

refined my prototypes based on the first two participants' feedback. In particular, my initial design of SFLAD#1 and SFLAD#2 are unfathomable for the participants due to the confusedness caused by the title and the lack of context. For example, in SFLAD#2, the initial title is the same as the other three prototypes, which is "My course progress – Week 8/15". However, the first two participants express universal doubts about the meaning of SFLAD#2. One misunderstood that SFLAD#2 is showing her own information because the initial title causes some ambiguity. As she said, "So, because this is my course progress, I thought this was telling me about me. But it's all about what the teacher has done." Another indicated, "If I'm halfway through the course, I wouldn't care what other teachers are doing. That part, I'm not understanding the relationship there." Based on their feedback, I realized that my initial intention to keep the titles consistent throughout the four prototypes is not applicable. The information in SFLAD#2 displays the teachers' information, which is not in line with the other three prototypes that focus on their own learning information. I then changed the title to "My dashboard - Course A - instructor information" and added context to the network graph (See Figure 5b) to make it more explicit. These refinements enabled me to refine these SFLADs to better reflect my theoretical intentions and contributed to my overall evaluation.

As a result of the semi-structured interviews with five participants with diverse backgrounds, I gained plenty of informative insights and useful suggestions about the four prototypes I designed. One frequent feedback I received is combing the peer-comparison with self-comparison, which this result is contradictory to the literature that emphasizes the significant role of self-comparison in increasing performance and persistence. (Schwendimann et al., 2017; Jivet, Scheffel, Drachsler & Specht, 2017; Jivet,

Scheffel, Specht & Drachsler, 2018; Teasley, 2017). Another big takeaway is the high demand for interactive design. Such as one participant mentioned,

> Yeah, I think I can summarize this basically into two suggestions. One is that make the first graph more interactive. By clicking on the rank, we will be able to know how the students spend their time in this class and how they're performing. Right? We already know how they're performing. Right? And then for the third graph, it would be most helpful if when I click on that, you'll be able to pop up with something like the fourth graph, right? How each section, how my classmates are performing, how they spend their time each week. And I can compare with them with the average, not just by the overall, but by week.

Therefore, as for the revised SFLAD prototypes, I will focus on exploring the meaningful interaction between the design and the learners that can enhance their online learning experiences.

CHAPTER 5

CONCLUSION

The purpose of this study was to explore the role of student ownership in the context of student-facing learning analytics dashboards (SFLADs). Specifically, the present study investigated student perceptions of the four proposed SFLADs that are framed by self-determination theory (SDT) emphasizing that student ownership mediates the positive association between student ownership and learning outcomes (e.g., deep-level learning, greater achievement, and higher persistence at learning activates).

The results of the current study indicate, yet with limited sample size, that the student ownership mediation model for increasing the effectiveness of SFLADs could be applied in a virtual learning context. However, unlike the proposition of SDT: the controlling social environments and the extrinsic goal framing will demotivate students (Vansteenkiste et al.), this study also shows that the majority of the participants has a positive emotion towards the design features embodying the concepts of the controlling social environments and the extrinsic goal framing. Therefore, the effectiveness of SFLADs is not assured by either design features and learning theory separately or a simple combination of them. This insight can inform the next iterative design process of prototyping, testing, analyzing, and refining. I discuss the implications of this study from two aspects including design implications and application implications in the following two sections.

Design Implications

Emotional and motivational suggestions. As we know, personalized Learning Analytics application is in high demand (Roberts, Howell & Seaman, 2017). Nowadays, a well-designed SFLAD should be highly relevant to individuals' needs instead of a display of a universal prescription to all the students. Thus, it is called for action to pay more attention to the students emotional and behavioral responses to the SFLADs designs prior to the content and visual designs. The learning behaviors and outcomes are intimately tied to learning experiences. The future SFLADs design will expand its focus from product design to an experience design (Walcutt & Schatz, 2019). SFLADs should serve as a learning map to inform the users of where they came from and where they can be led to by depicting the meaningful and relevant personal informatics. SFLADs surely do not belong to the instructors or the educators or the designers to supplement the pedagogical and instructional toolkits. It is a powerful tool for students to support data-informed decision-making in their own learning trajectory. Most participants in the study express their emotions as they saw the proposed SFLADs. As we acknowledge, when people encounter a new thing, the first reaction is emotionally related, such as like or dislike. This result could show us the importance of producing an enjoyable user experience. It can change the perception of the product to develop an optimal learning outcome, such as deep-level learning, more significant achievement, and higher persistence at learning activities.

Even though, in this study, only one participant (1/5) is comfortable with making an education or learning-related decision completely based on the information on her dashboards (e.g., data-informed learning environment) for a timesaving reason, all five participants surprisingly express a positive perception of the peer-reference design (e.g.,

SFLAD#3). Moreover, they convey the confidence about using that information to make decisions regarding their own learning because that information is well-informed and high relevant to their needs (e.g., informing them where they are at in class, and what they need to do to score higher than the average). This result is contradictory to other literature (Schwendimann et al., 2017; Jivet, Scheffel, Drachsler & Specht, 2017; Jivet, Scheffel, Specht & Drachsler, 2018; Teasley, 2017). I do think these contradictory results provide me with more informative information about the design of SFLADs in terms of student ownership or learning experience design. As I mentioned before, this study is the beginning step of an iterative design process.

In addition, I believe that a major reason that only one participant is confident to make the data-informed decisions is a limitation on the order of interview questions. They were asked to answer this question before reviewing any SFLAD prototypes. In this condition, they automatically situated this question in the context of their current dashboard, which is neither student-facing nor well-designed. Later, after reviewing the SFLAD prototypes, they start discovering the affordance of the data-informed SFLADs.

Student ownership mediation model sersus learning experience mediation model. In the exploration phase, I framed a student ownership mediation model (See Figure 2) based on self-determination theory (SDT; Deci and Ryan, 2008) and mapped out the corresponding design conjectures (See Figure 2) drew upon Sandoval's (2014) techniques. The general theory-based inference of this study is that student ownership (based on SDT) will improve student perceptions of learning in an autonomy-supportive SFLAD context. However, the study results are mixed regarding the role of an autonomy-supportive environment in student perception in the SFLAD context. For instance,

SFLAD#2, which is an embodiment of autonomy-supportive factor, received the lowest score in the perceived usefulness and ease of use questionnaires and results in negative emotional responses. Similarly, SFLAD#4, a representation of intrinsic goal framing, gained a less-than-positive reaction. Participants expressed more interest in the extrinsic goal framing and peer-comparison prototypes (e.g., SFLAD#1 and SFLAD#3). This contradictory result shows that the need for autonomy was not associated with satisfaction and success in online learning. So, what has been missing in this student ownership mediation model? I think it is the messiness of the practice (e.g., an online learning environment). This result also confirmed that the complex nature of the application of SDT in the online learning environment, and a 'one size fits all' approach in an online context does not work. These findings shed lights on rethinking the application of SDT in the online learning environment, such as the dichotomous conceptualization of autonomous and controlling motivation within SDT could hardly explain student perceptions regarding online learning due to the diversity of its users and the various confounding variables in the online setting. When SDT is directly applied to practice, there is a challenge of bringing the theory into the messiness of the practice. How should I address this unexpected but inevitable confounding factors and then make use of such messiness?

With respect to the next iteration of user testing and SFLAD prototypes, I will make two significant revisions. First off, I will integrate different constructs that are derived from different theories and invite the combination of these constructs into the design and evaluation of online learning. SDT as a motivational theory is hard to address online learning problems separately. For example, adult learning theories (e.g.,

Andragogy and Heutagogy) was mentioned in some articles that adopt SDT as their theoretical framework (Cercone, 2008; Beaven et al., 2014). These articles state that there is a close connection between SDT and andragogy that might be worth to pay attention to regarding the design of an online learning environment. For instance, Cercone (2008) presents five assumptions of andragogy that will effectively motivate online adult learners to be more engaged and self-directed. These assumptions primarily describe what adult learners might be like and what kind of instructions that teachers should provide in order to help them become self-directed learners. So, such assumptions should be taken into account when designing an online learning environment. Secondly, another concentration of my next iteration will focus on translating the incomprehensible jargon design (theories) into an intuitive design (practice). This process is referring to learning experience design in prevalent literature in distance learning (Walcutt and Schatz, 2019). Instead of using student ownership model, which only focus on exploring the motivational constructs in an online learning environment, a new learning experience model will be framed. In the new model, I will add constructs from other learning theories, such as adult learning assumptions to enrich the design and intervention of SFLAD prototypes. The most significant revision in the new model will be the usability test regarding the learning experiences design. Schatz (2019) states, “poor usability and breakdowns with other nonfunctional requirements could become insurmountable barriers to the effective and efficient use of technology.” (p. 84) Indeed, it is a severe challenge of conducting a proper and effective usability test of learning experiences design. This task requires the iterative testing followed by the iterative design. User Experience (UX) may inspire me of the usability principles in many practical ways

(Hassenzahl & Tractinsky, 2006) because however innovative a new intervention, it is meaningless if people in a real-world context do not know how to use it. Therefore, a holistic UX method should be applied in my next iteration. This could be a system level usability test, which means across its various users and stakeholders. Reflect on this study, I only conduct the questionnaires and interview with participants. This might limit the insights from other usability stakeholders such as instructors, administrators, and even engineers and developers who monitor data models and create the applications in a learning environment. This system usability might ensure the reliability and effectiveness of the future SFLAD prototypes.

Application Implications

The lower penetration rate of SFLADs is one of my biggest concerns in modern education because the number of online learners is expected to continue rising. How can the effectiveness of SFLADs be accurately measured if students don't know it exists? Also, SFLAD#2 is an example of a design intention being stretched that little bit too far. I intended to provide the students with entirely student ownership by emphasizing the importance of accessibility of teachers' information. However, the graphs I selected and created are not suitable for this design. I also ask the participants if they value teacher information in their online learning; all of them express a positive attitude and perceptions. One participant comments on SFLAD#2, "I love the time-spend of teachers because I would choose someone that spends a lot of time on course materials. That makes me feel a lot better, and if the teacher spends a lot of time on discussion forums, that means they take the time to provide feedback, and I need that as a student."

Therefore, the accessibility of teachers' information is in demand because such information is deemed to be informative for students to make decisions, especially for those data-driven decisions in a virtual learning environment. However, how can we integrate such information into the current system? I believe it is not just about answering how to design a good SFLAD that embody a learning theory. It is about exploring a path to develop an ecosystem of online learning. Since SFLADs as one part of this ecosystem, how can we make the best use of it to improve the development of such an ecosystem? For instance, we can continue to synthesize theories and practices from diverse disciplines and allow the concept of human-centered design to seep into our innovation and evaluation process.

Another interesting finding in this study is how my competing roles as interested designer and disinterested researcher positioned me in terms of guiding interviews and probing participants comments on my prototypes. It was quite frustrating when I first found out the results were different from what I expected. Then I re-examined my design and reviewed more of the literature. I revisited the informed exploration phase to some point. That is how I located the critical missing part of this study and came up with these implications above. DBR, as a robust research method, has allowed me to ground this study itself in the needs, constraints, and interactions of local practice, and provide a way for exploring how theoretical perspectives can be transformed into effective learning in the online learning settings.

REFERENCES

Aguilar, S. J. (2016). Perceived Motivational Affordances: Capturing and Measuring Students' Sense-Making Around Visualizations of their Academic Achievement Information.

Brown, J.M., Miller, W.R. and Lawendowski, L.A. (1999) The Self-Regulation Questionnaire. In: Vandecreek, L. and Jackson, T.L., Eds., Innovations in Clinical Practice: A Sourcebook, Vol. 17, Professional Resource Press/Professional Resource Exchange, Sarasota, FL, 281-292.

Butler, D. L., & Winne, P. H. (1995). Feedback and self-regulated learning: A theoretical synthesis. *Review of educational research, 65*(3), 245-281.

Bannan-Ritland, B. (2003). The role of design in research: The integrative learning design framework. *Educational researcher, 32*(1), 21-24.

Bannan-Ritland, B. & Baek, J. (2008). Investigating the act of design in design research: The road taken. In A.E. Kelly, R.A. Lesh, & J. Baek (Eds.), *Handbook of design research methods in education: Innovations in science, technology, mathematics and engineering* (pp. 299-319). Mahway, NJ: Taylor & Francis.

Bannan, B. (2013). The integrative learning design framework: An illustrated example from the domain of instructional technology. In T. Plomp & N. Nieveen (Eds.), *An introduction to educational design research, Second Edition* (pp. 114–133). Enschede, Netherlands: Netherlands Institute for Curriculum Development.

Beaven, T., Hauck, M., Comas-Quinn, A., Lewis, T., & de los Arcos, B. (2014). MOOCs: Striking the right balance between facilitation and self-determination. *MERLOT Journal of Online Learning and Teaching, 10*(1), 31-43.

Bodily, R., & Verbert, K. (2017). Review of research on student-facing learning analytics dashboards and educational recommender systems. *IEEE Transactions on Learning Technologies, 10*(4), 405-418.

Bodily, R., & Verbert, K. (2017, March). Trends and issues in student-facing learning analytics reporting systems research. In *Proceedings of the seventh international learning analytics & knowledge conference* (pp. 309-318). ACM.

Broos, T., Peeters, L., Verbert, K., Van Soom, C., Langie, G., & De Laet, T. (2017). Dashboard for Actionable Feedback on Learning Skills: How Learner Profile Affects Use. In *ARTEL@ EC-TEL*.

Barab, S. (2014). Design-based research: A methodological toolkit for engineering change. In *The Cambridge Handbook of the Learning Sciences, Second Edition*. Cambridge University Press.

Barab, S. A., & Squire, K. (2004). Design-based research: Putting a stake in the ground. *The Journal of the Learning Sciences, 13*(1), 1–14.

Bewick, V., Cheek, L., & Ball, J. (2004). Statistics review 10: further nonparametric methods. *Critical care, 8*(3), 196.

Cercone, K. (2008). Characteristics of adult learners with implications for online learning design. *AACE journal, 16*(2), 137-159.

Charleer, S., Klerkx, J., Duval, E., De Laet, T., & Verbert, K. (2016, September). Creating effective learning analytics dashboards: Lessons learnt. In *European Conference on Technology Enhanced Learning* (pp. 42-56). Springer, Cham.

Charleer, S., Klerkx, J., Santos, J. L., & Duval, E. (2013). Improving awareness and reflection through collaborative, interactive visualizations of badges. *ARTEL@ EC-TEL, 1103,* 69-81.

Collins, A., & Halverson, R. (2018). *Rethinking education in the age of technology: The digital revolution and schooling in America*. Teachers College Press.

Cronbach, L.J., 1951. Coefficient alpha and the internal structure of tests. *Psychometrika 16* (3), 297–334.

Edelson, D. C. (2002) Design Research: What We Learn When We Engage in Design, *Journal of the Learning Sciences*, 11:1, 105-121, DOI: 10.1207/S15327809JLS1101_4

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS quarterly, 319-340.

Deci, E. L., & Ryan, R. M. (2008). Self-determination theory: A macrotheory of human motivation, development, and health. *Canadian psychology/Psychologie canadienne, 49*(3), 182.

Festinger, L. (1954). A theory of social comparison processes. *Human relations, 7*(2), 117-140.

Few, S. (2006). *Information Dashboard Design: The Effective Visual Communication of Data*. O'Reilly Media. Retrieved March 25, 2019, from https://dl.acm.org/citation.cfm?id=1206491

Friendly, M., & Denis, D. (2005). The early origins and development of the scatterplot. *Journal of the History of the Behavioral Sciences, 41*(2), 103-130.

Galaige, J., Torrisi-Steele, G., Binnewies, S., & Wang, K. (2018). What is Important in Student-Facing Learning Analytics? A User-Centered Design Approach.

González-Torres, M. C., & Torrano, F. (2008). Methods and instruments for measuring self-regulated learning. *Handbook of Instructional Resources and their Applications in the Classroom, Nueva York, Nova Science*, 201-219.

Hassenzahl, M., & Tractinsky, N. (2006). User experience-a research agenda. *Behaviour & information technology*, *25*(2), 91-97.

Heiberger, R. M., & Robbins, N. B. (2014). Design of diverging stacked bar charts for Likert scales and other applications. *Journal of Statistical Software*, *57*(5), 1-32.

Hoewe, J. (2017). Manipulation Check. *The International Encyclopedia of Communication Research Methods*, 1-5.

Ifenthaler, D., Gibson, D., & Dobozy, E. (2018). Informing learning design through analytics: Applying network graph analysis. *Australasian Journal of Educational Technology*, *34*(2), 117-132.

Jivet, I., Scheffel, M., Drachsler, H., & Specht, M. (2017, September). Awareness is not enough: pitfalls of learning analytics dashboards in the educational practice. In *European Conference on Technology Enhanced Learning* (pp. 82-96). Springer, Cham.

Jivet, I., Scheffel, M., Specht, M., & Drachsler, H. (2018, March). License to evaluate: Preparing learning analytics dashboards for educational practice. In *Proceedings of the 8th International Conference on Learning Analytics and Knowledge* (pp. 31-40). ACM.

Johnson, L., Becker, S. A., Cummins, M., Estrada, V., Freeman, A., & Hall, C. (2016). *NMC horizon report: 2016 higher education edition* (pp. 1-50). The New Media Consortium.

Kennedy-Clark, S. (2013). Research by Design: Design-Based Research and the Higher Degree Research student. *Journal of Learning Design*, *6*(2), 26-32.

Klerkx, J., Verbert, K., and Duval, E. (2017). Learning Analytics Dashboards. In Lang, C., Siemens, G., Wise, A. F., and Gaevic, D., editors, The Handbook of Learning Analytics, pages 143–150. *Society for Learning Analytics Research (SoLAR),* Alberta, Canada, 1 edition.

Kit, D. The Field Guide to Human-Centered Design. *IDEO. org.*

Kitto, K., Lupton, M., Davis, K., & Waters, Z. (2017). Designing for student-facing learning analytics. *Australasian Journal of Educational Technology*, *33*(5), 152-168.

Knight, S. and Buckingham Shum, S. (2017). Theory and Learning Analytics. In Lang, C., Siemens, G., Wise, A. F., and Gaevic, D., editors, *The Handbook of Learning*

Analytics, pages 17–22. Society for Learning Analytics Research (SoLAR), Alberta, Canada, 1 edition.

Lang, C., Siemens, G., Wise, A., & Gasevic, D. (Eds.). (2017). Handbook of learning analytics. SOLAR, Society for Learning Analytics and Research.

Lim, L., Dawson, S., Joksimovic, S., & Gašević, D. (2019, March). Exploring students' sensemaking of learning analytics dashboards: Does frame of reference make a difference?. In *Proceedings of the 9th International Conference on Learning Analytics & Knowledge* (pp. 250-259). ACM.

Marzouk, Z., Rakovic, M., Liaqat, A., Vytasek, J., Samadi, D., Stewart-Alonso, J., ... & Nesbit, J. C. (2016). What if learning analytics were based on learning science?. *Australasian Journal of Educational Technology*, *32*(6).

Paul A. David, Oxford Internet Institute (Aug 2004): Towards a cyberinfrastructure for enhanced scientific collaboration: providing its 'soft' foundations may be the hardest part Papamitsiou, Z., & Economides, A. A. (2014). Learning analytics and educational data mining in practice: A systematic literature review of empirical evidence. *Journal of Educational Technology & Society, 17*(4), 49-64.

Pellegrino, J. W. (2014). A learning sciences perspective on the design and use of assessment in education. In *The Cambridge handbook of the learning sciences* (pp. 233-252).

Plomp, T. (2013). Educational design research: An introduction. *Educational design research*, 11-50.

Park, Y., & Jo, I. H. (2015). Development of the learning analytics dashboard to support students' learning performance. *Journal of Universal Computer Science*, *21*(1), 110.

Reimers, G., Neovesky, A., & der Wissenschaften, A. (2015). Student focused dashboards. *7th International Conference on Computer Supported Education (Lisbon)*

Roberts, L. D., Howell, J. A., & Seaman, K. (2017). Give me a customizable dashboard: Personalized learning analytics dashboards in higher education. *Technology, Knowledge and Learning*, *22*(3), 317-333.

Santos, J. L., Govaerts, S., Verbert, K., & Duval, E. (2012, April). Goal-oriented visualizations of activity tracking: a case study with engineering students. In *Proceedings of the 2nd international conference on learning analytics and knowledge* (pp. 143-152). ACM.

Sedrakyan, G., Leony, D., Muñoz-Merino, P. J., Kloos, C. D., & Verbert, K. (2017, September). Evaluating student-facing learning dashboards of affective states. In

European Conference on Technology Enhanced Learning (pp. 224-237). Springer, Cham.

Schumacher, C., & Ifenthaler, D. (2018). Features students really expect from learning analytics. *Computers in human behavior, 78*, 397-407.

Schwendimann, B. A., Rodriguez-Triana, M. J., Vozniuk, A., Prieto, L. P., Boroujeni, M. S., Holzer, A., ... & Dillenbourg, P. (2017). Perceiving learning at a glance: A systematic literature review of learning dashboard research. *IEEE Transactions on Learning Technologies, 10*(1), 30-41.

Smagorinsky, P. (2008). The method section as conceptual epicenter in constructing social science research reports. *Written Communication, 25*(3), 389-411.

Siemens, G., & Baker, R. S. (2012). Learning analytics and educational data mining. *Proceedings of the 2nd International Conference on Learning Analytics and Knowledge - LAK 12*. doi:10.1145/2330601.2330661

Siemens, G., & Gasevic, D. (2012). Guest editorial--learning and knowledge analytics. *Educational Technology & Society, 15*(3), 1-3.

Siemens, G. (2012, April). Learning analytics: envisioning a research discipline and a domain of practice. In *Proceedings of the 2nd international conference on learning analytics and knowledge* (pp. 4-8). ACM.

Teasley, S. D. (2017). Student Facing Dashboards: One Size Fits All?. *Technology, Knowledge and Learning, 22*(3), 377-384.

Walcutt, J. J., & Schatz, S. (Eds.). (2019). *Modernizing Learning: Building the Future Learning Ecosystem.* Department of Defense (DOD), Deputy Assistant Secretary of Defense for Force Education and Training. eBook ISBN: 978-0-16-095091-9.

Wise, A., Zhao, Y., & Hausknecht, S. (2014). Learning analytics for online discussions: Embedded and extracted approaches. *Journal of Learning Analytics, 1*(2), 48-71.

Winne, P. H., & Azevedo, R. (2014). Metacognition. In K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (2nd ed., pp. 63–87). Cambridge, England: Cambridge University Press.

Collins, A., & Halverson, R. (2018). *Rethinking education in the age of technology: The digital revolution and schooling in America*. Teachers College Press.

Vansteenkiste, M., Lens, W., & Deci, E. L. (2006). Intrinsic versus extrinsic goal contents in self-determination theory: Another look at the quality of academic motivation. *Educational psychologist, 41*(1), 19-31.

Verbert, K., Duval, E., Klerkx, J., Govaerts, S., & Santos, J. L. (2013). Learning analytics dashboard applications. *American Behavioral Scientist, 57*(10), 1500-1509.

APPENDICES A

IRB APPROVAL DOCUMENT

ASU Knowledge Enterprise Development

EXEMPTION GRANTED

Steven Zuiker
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Dear Steven Zuiker:

On 4/15/2019 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Investigating the role of Student Ownership in the design of Student-facing Learning Analytics Dashboards (SFLADs) in relation to student perceptions of SFLADs
Investigator:	Steven Zuiker
IRB ID:	STUDY00010053
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Revised Siyuan Li-Form-Social-Behavioral-Protocol.docx, Category: IRB Protocol; • 2nd Revision- Siyuan Li-short-consent.pdf, Category: Consent Form; • Email to Participants.pdf, Category: Recruitment Materials; • Interview scripts and questions.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • citiCompletionReport5729719-Si Yuan Li.pdf, Category: Other (to reflect anything not captured above);

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 4/15/2019.

APPENDIX B

INTERVIEW PROTOCOL

My name is Siyuan. I am conducting a research study to investigate student perceptions of the design features of the learning dashboards in order to generate evidence to improve the student-facing learning analytics dashboards design.

Today, I will be conducting the interview. This interview will last anywhere from 30-60 minutes. Your responses will remain confidential, and this interview will not be shared with anyone. Is it ok if I record this conversation?

Demography Question

What is your age?

Level of Familiarity with the student-facing learning analytics dashboards, Understanding of Student Ownership

1. Have you used a dashboard for your online course?

2. How long have you been using dashboards for your online learning?

3. How often do you use the dashboard?
    a. Several times a day
    b. About once a day
    c. 2 or 3 times a week
    d. About once a week

4. Have you heard about student-facing learning analytics dashboards?

- If the answer is yes, then ask them to describe what it is.
- If the answer is no, brief explain what it is, such as a student-center dashboard that focuses on tracking and analyzing the learning data from students' online learning activities and report it directly to students.

5. Do you think your current dashboard is a student-facing learning analytics dashboard? Why/why not?

Next, I will ask you about the sense of ownership you might have from your online learning experiences.

6. Will you be comfortable with deciding to enroll in or withdraw from a course only based on the information on your dashboards (e.g., syllabus, grades, and feedback from instructors?) Why/why not?

7. Which online learning environment do you think will make you more comfortable with making the decisions above? The options include:
    - autonomous contexts (e.g., data-informed learning environments: using analytics data as a reference to plan your own learning activities)

- partial autonomous (e.g., direct instruction: an instructor-centered model of teaching with very little participation from you)
- blended contexts (e.g., guided instruction: you take an active role in the educational process, and the instructor acts as a facilitator)?

Why?

Then, let me explain to you what student ownership is in this study:

a) the freedom of choice that you have regarding your own learning activities (e.g., enroll in or withdraw from a course)

b) the opportunity of utilizing the information that is relevant and meaningful to you (e.g., only visualizing the data that is meaningful to you).

8. After knowing the definition of student ownership, do you think you have been afforded student ownership in any way in your online learning experiences? Why?

Recall, for a moment, a course that you took or am taking within one year.

Do you have a course in mind? [Wait for response] Great, what course did you choose? When did you take it?

I am now going to show you a student-facing learning analytics dashboard of your learning progress in that course. It visualized a hypothetical halfway of a 15-week academic term, which is week 8 course process.

Autonomy-supportive context (SFLAD#2)

[Show SFLAD#2]
Here is the first student-facing learning analytics dashboard

9. What is this student-facing learning analytics dashboard about?

10. What was the first thing you noticed about the student-facing learning analytics dashboard? Why was that noticeable?

11. Have you seen or used similar student-facing learning analytics dashboard?

Controlling social environments (*SFLAD#1)*

[Show SFLAD#1]
I am now going to show you another student-facing learning analytics dashboard for the same course.

12. What is this student-facing learning analytics dashboard about?

13. What was the first thing you noticed about the student-facing learning analytics dashboard? Why was that noticeable?

14. Have you seen or used similar student-facing learning analytics dashboard?

Intrinsic goal framing (SFLAD#4)

[Show SFLAD#4]
I am now going to show you the third student-facing learning analytics dashboard for the same course.

15. What is this student-facing learning analytics dashboard about?

16. What was the first thing you noticed about the student-facing learning analytics dashboard? Why was that noticeable?

17. Have you seen or used similar student-facing learning analytics dashboard?

Extrinsic goal framing (SFLAD#3)

[Show SFLAD#3]
I am going to show you the fourth student-facing learning analytics dashboard for the same course.

18. What is this student-facing learning analytics dashboard about?

19. What was the first thing you noticed about the student-facing learning analytics dashboard? Why was that noticeable?

20. Have you seen or used similar student-facing learning analytics dashboard?

[Show SFLAD #1, #2, #3, #4]
Here are all four student-facing learning analytics dashboards. The following questions will ask you to compare them to one another.

21. Is there anything you found will help you decide on your learning activities (e.g., withdraw the courses) regarding how the information was presented in one or more of the student-facing learning analytics dashboards? Is there anything you didn't find will help you make such a decision?

22. Is there anything you found meaningful and relevant to your learning goals regarding how the information was presented in one or more of the student-facing learning analytics dashboards? Is there anything you didn't find meaningful and relevant?

23. Which student-facing learning analytics dashboards independently or combinedly do you think would make you more motivated to change your learning behavior in the course? Why? What's motivating about it?

24. Which student-facing learning analytics dashboards independently or combinedly do you think would make you more motivated to change your learning skills in the course? Why? What's motivating about it?

Here is the perceived usefulness and ease of use (PUEU) questionnaire. Please fill in the questionnaire for each student-facing learning analytics dashboard.

Wrap up

Here are all five student-facing learning analytics dashboards again.

25. Which of the four student-facing learning analytics dashboards that I've shown you do you feel to be most useful to have a positive impact on your learning outcomes? Why?

26. Aside from what these student-facing learning analytics dashboards show, what other suggestions you have regarding the SFLADs design? Why?

APPENDIX C

QUESTIONNAIRE INSTRUMENT

Please indicate how strongly you agree or disagree with all the following statements which apply to you by selecting a number from 1 (strongly disagree) to 7 (strongly agree):

Scale:
1=Strongly disagree, 2=Somewhat disagree, 3=Disagree, 4=Neutral, 5=Agree, 6=Somewhat agree, 7=Strongly agree.

PERCEIVED USEFULNESS

1. Using the SFLAD in my online learning would enable me to accomplish tasks more quickly
2. Using the SFLAD would improve my online learning performance
3. Using the SFLAD in my online learning would increase my productivity
4. Using the SFLAD would enhance the effectiveness of my online learning
5. Using the SFLAD would make it easier to learn online
6. I would find the SFLAD useful in my online learning

PERCEIVED EASE OF USE

1. Learning to operate the SFLAD would be easy for me
2. I would find it easy to get the SFLAD to do what I want it to do
3. My interaction with the would be clear and understandable
4. I would find the SFLAD to be flexible to interact with
5. It would be easy for me to become skillful at using the SFLAD
6. I would find the SFLAD easy to use